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SUSTAINING MEMBERS

THE USE OF 2,4-D TO INTENSIFY THE SKIN COLOR OF PONTIAC POTATOES[1]

R. E. Nylund[2]

Introduction

The value to potato growers of an intense red periderm (skin) color in red-skinned potato varieties has been demonstrated by the rapid acceptance of the Red Pontiac in preference to the lighter-red variety, Pontiac, from which this deeper-red mutant arose and by the premium being paid by consumers for red potatoes whose skin color has been further intensified through the use of waxes containing red vegetable dye. However, the sale of artificially colored potatoes is prohibited in several states and in others, complaints regarding dyed potatoes have been expressed. Because of these factors, there is considerable interest in alternative methods of improving skin color. One method is through the application of plant-growth regulators to potato vines in the field.

In 1948, Fults and Schaal (3) first reported on the effects of field applications of 2,4-D on the skin color of Bliss Triumph tubers and suggested the possibility of using plant growth regulators in this way to intensify skin color of red varieties of potatoes. Ellis (1) confirmed the observations of Fults and Schaal. Later, more extensive work by Fults, *et al.* (9) showed that 2,4-D would also intensify the skin color of Red McClure potatoes and that the improved skin color remained stable during the storage period.

Other studies have shown that the application of 1/4 to 1/2 pound of 2,4-D per acre had no effect on the nitrate content of Red McClure potato tubers (2), increased the protein content of such tubers by 27 per cent (10), and increased the free glutamic acid content of the tubers while reducing the concentration of eleven other amino acids (9).

Payne, *et al.* (10) also found that the application of 1/2 pound of 2,4-D increased the specific gravity of Red McClure potatoes. Prince and Blood (12) showed that the application of low rates of 2,4-D (1/5 pint of 40 per cent 2,4-D per acre) increased the specific gravity of six varieties of potatoes whereas higher rates (1 1/2 pints 2,4-D) had no effect on the specific gravity of tubers from treated vines. This effect of higher rates may explain why Peterson and Gwinn (11), using 2 pounds of 2,4-D per acre obtained no increase in the specific gravity of four varieties of potatoes.

In 1949, the author, in carrying out a preliminary study to determine the relative tolerance of ten potato varieties to 2,4-D applied at various stages of growth, observed that tubers from sprayed plots of red-skinned varieties were either darker red or lighter red than tubers from untreated plants depending on the stage of growth of the plants at the time of the 2,4-D application. When the sodium salt of 2,4-D was sprayed at the rate of 2 pounds acid equivalent per acre on plants 6-8 inches tall, tubers of the five red varieties in the test (Pontiac, Satapa, Waseca, Red Warba, and Triumph) tended to be less red than normal. A similar application

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made in the late bud stage had no effect on color, whereas an application made on July 11 when most varieties were in the full bloom stage resulted in a marked intensification in skin color of all the red-skinned varieties. All of the 2,4-D applications, however, seriously reduced yield of potatoes, the average reduction in yield for the ten varieties being approximately 30 per cent. None of the 2,4-D treatments affected the specific gravity of tubers of any of the ten varieties in the test nor did they affect the amount of sprouting of any of the varieties stored from harvest until the following March. A small scale growth experiment in which potatoes from each of the sprayed plots and from the unsprayed control were fed to laboratory rats (5 rats per treatment) for a period of four weeks indicated that no detectable quantities of toxic material were present in the treated potatoes.*

During the same summer, in another test to determine the effectiveness of 2,4-D and MCP (2 methyl-4 chlorophenoxyacetic acid) as weedicides for Irish Cobbler potatoes, bud-stage applications of 1/4 to 1/2 pound 2,4-D or 1 pound MCP did not reduce yields or affect the specific gravity of potatoes (5).

On the basis of the results from the above mentioned experiments and those conducted elsewhere, a series of experiments were conducted from 1950 to 1954 to determine the rate, time, and method of application of 2,4-D and/or MCP which would give the greatest improvement in skin color with the least effects on crop yields. Part of the results of the 1950 experiment have been published elsewhere (6, 7).

Materials and Methods

Inasmuch as several experiments were conducted and each was modified somewhat on the basis of previous results, the materials and methods used are discussed in the results section for each experiment. However, some of the methods used were common throughout the experiments. In all experiments 2,4-D was applied as the alkanolamine salt and MCP, where used, was also an amine salt. The rates given in the discussion of results refer to the rate of acid equivalent of the growth regulator used. All growth regulator treatments were applied in 40 gallons of water per acre at pressures of 35-50 pounds using a stainless steel 2- or 4-gallon knapsack sprayer fitted with a flat-spray nozzle.

At harvest, yields of U.S. No. 1 size tubers (1 7/8" minimum) were recorded. In 1950, visual ratings of periderm color of the potato tubers in each plot were made in the field at digging, using a numerical scale of 1 to 8 in which 1 = lightest red and 8 = most intense red. The tubers from the untreated control plot of one replication were given a value of 4 and those from the remaining control and treated plots were given values relative to this control plot. In all later experiments, tuber color was rated in the laboratory by selecting, from the tubers in all plots, five tubers ranging in color from the lightest red to the most intense red present. These tubers were given a number from 1 (lightest red) to 5 (darkest red). Each tuber in the fifteen- to thirty-pound lots selected at random from each plot was classified as to color by visual comparison

*The author wishes to thank Dr. M. O. Schultze of the Department of Biochemistry for conducting these feeding tests.

with the five standard tubers. An average color rating for each lot was thus obtained from the frequency distribution of the tuber color ratings.

In those experiments in which specific gravity determinations were made, samples of tubers weighing 15 to 30 pounds were weighed in air and in water to obtain the average specific gravity of the lot.

Results

Experiment No. 1 — 1950:

Pontiac potatoes planted in muck soil at Excelsior, Minnesota, on May 15 were sprayed over the row with 2,4-D and MCP at ¼, ½, and 1 pound per acre at each of four stages of growth: 6-8 inch stage (June 12), 12-18 inch stage (June 26), bud stage (July 10), and when plants were beginning to senesce (August 21) at which time tubers averaged two ounces in weight. Each plot consisted of a 50-foot row (50 hills) and was replicated four times. The growth regulators were applied as complete coverage sprays. Three plants were removed from each plot at two-week intervals during the growing season to determine the effects of the treatments on vine growth. Field color notes and tuber yields were obtained at harvest on September 26. The specific gravities of tubers from each plot were determined shortly after harvest. Ascorbic acid contents of five-tuber samples from each plot were determined after three months' storage using the 2,6-dichlorophenolindophenol visual titration method (13).

The effects of the 2,4-D and MCP treatments on yields, periderm color, specific gravity and ascorbic acid content are shown in table 1. Most of the 2,4-D and MCP applications tended to reduce yields of U.S. No. 1 tubers with the 2,4-D treatments causing the greatest reductions in yields. Applications of 1 pound of 2,4-D to plants 6-8 inches tall and ¼ to 1 pound of 2,4-D to plants 10-12 inches tall resulted in particularly serious yield reductions. MCP was apparently not so toxic as 2,4-D.

Field color ratings indicate that applications of either 2,4-D or MCP to plants in the bud stage were more effective in intensifying tuber skin color than were earlier or later applications. Variations in rates of application of the chemicals did not appear to materially affect the degree of intensification obtained. On the average, 2,4-D tended to intensify tuber color slightly more than MCP.

Neither the specific gravities nor the ascorbic acid contents of the potatoes were affected by the application of 2,4-D or MCP.

That the reduced yields resulting from the chemical treatments was due to an inhibition of vine growth is indicated by the data given in table 2. The applications of 2,4-D made on June 26 resulted in greatly reduced vine weight following treatment; these treatments also caused the greatest reduction in yield (Table 1).

Experiment No. 2 — 1951:

On May 17, 1951, Pontiac potatoes were planted in a silt loam soil at the Red River Valley Potato Research Farm at Grand Forks, North Dakota. 2,4-D and MCP were each applied at rates of ¼, ½, and 1 pound per acre to two plots in each of five replications on July 24. On this date the potato plants were in full bloom and tubers under the hills were 1 - 1½ inches in diameter. On August 17, a second application

TABLE 1.—*Yields of U.S. No. 1 tubers, skin color ratings, specific gravities, and ascorbic acid contents of tubers from Pontiac plants receiving various rates of 2,4-D and MCP at four stages of growth. University Fruit Breeding Farm, 1950.*

Date of Application and Stage of Growth	Rate of Chemical Applied:	Yields/ Acre:	Tuber Skin Color Ratings:	Specific Gravity of Tubers:	Ascorbic Acid Content:
	Pounds	Bushels			Mg. Cent.
Untreated	——	554	4.0	1.057	12.5
June 12 (6-8" Tall)	¼ lb. 2,4-D	470	4.5	1.064	10.9
	½ lb. 2,4-D	447	4.8	1.063	11.4
	1 lb. 2,4-D	379	4.2	1.060	11.1
	¼ lb. MCP	453	4.8	1.061	10.8
	½ lb. MCP	476	4.0	1.054	12.0
	1 lb. MCP	471	4.8	1.064	11.1
June 26 (12-16" Tall)	¼ lb. 2,4-D	382	4.5	1.064	10.8
	½ lb. 2,4-D	373	5.5	1.057	10.8
	1 lb. 2,4-D	325	5.2	1.052	11.5
	¼ lb. MCP	480	4.2	1.066	11.7
	½ lb. MCP	435	4.0	1.057	14.0
	1 lb. MCP	463	4.5	1.055	11.3
July 10 (Bud Stage)	¼ lb. 2,4-D	428	5.5	1.055	11.8
	½ lb. 2,4-D	439	6.0	1.052	12.3
	1 lb. 2,4-D	435	6.2	1.060	11.3
	¼ lb. MCP	465	5.8	1.051	11.3
	½ lb. MCP	479	4.8	1.062	12.2
	1 lb. MCP	457	5.8	1.060	12.0
Aug. 21 (Senescent)	¼ lb. 2,4-D	458	4.2	1.048	11.7
	½ lb. 2,4-D	534	4.8	1.056	11.4
	1 lb. 2,4-D	423	4.5	1.056	11.3
	¼ lb. MCP	543	4.8	1.060	12.0
	½ lb. MCP	478	4.8	1.060	10.2
	1 lb. MCP	488	4.8	1.060	12.8
L.S.D., 5 per cent level		107	0.9	n.s.	n.s.
L.S.D., 10 per cent level		142	1.3	——	——

of each of the above rates of 2,4-D and MCP was made to one of the previously sprayed plots in each replication. Each plot consisted of a single row 43 feet long. Plot rows were separated by untreated border rows to minimize spray drift from one treated row to another. Four unsprayed rows bordered by untreated rows served as control plots in each replicate. The sixteen plots were randomized in each of five replications. The 2,4-D and MCP were applied as complete coverage sprays. Yields of U.S. No. 1-size tubers were obtained at harvest on September

TABLE 2.—*Fresh weights of tops of unsprayed and of 2,4-D and MCP-sprayed Pontiac potato plants at various intervals during the growing season. University Fruit Breeding Farm, 1950.*

Date of Application	Rate of Chemical Applied	Mean Fresh Weights per Plant of Potato Vines on:					
		June 12	June 27	July 10	July 24	Aug. 7	Aug. 21
	Pounds	Grams	Grams	Grams	Grams	Grams	Grams
Untreated	——	32	351	874	1347	1608	1264
June 12 (6-8" tall)	¼ lb. 2,4-D	14	166	612	1460	1596	1331
	½ lb. 2,4-D	23	202	748	1744	1562	1191
	1 lb. 2,4-D	34	224	745	1187	1373	900
	¼ lb. MCP	32	310	820	1388	1550	1467
	½ lb. MCP	24	166	684	1143	1206	1357
	1 lb. MCP	42	243	874	1478	1676	1165
June 26 (12-16" tall)	¼ lb. 2,4-D	24	260	654	1010	1006	767
	½ lb. 2,4-D	23	287	563	907	972	729
	1 lb. 2,4-D	29	273	521	960	870	570
	¼ lb. MCP	26	254	737	1222	1490	1183
	½ lb. MCP	41	241	548	1308	1316	1202
	1 lb. MCP	27	232	510	907	1100	908
July 10 (Bud stage)	¼ lb. 2,4-D	36	312	835	1350	1604	1244
	½ lb. 2,4-D	28	264	771	1592	1729	1437
	1 lb. 2,4-D	29	351	824	1267	1501	840
	¼ lb. MCP	38	278	643	1400	1437	1490
	½ lb. MCP	33	223	870	1361	1444	915
	1 lb. MCP	26	218	874	1547	1668	1464
Aug. 21	¼ lb. 2,4-D	33	272	923	1596	1975	1513
	½ lb. 2,4-D	39	284	968	1566	1963	1630
	1 lb. 2,4-D	22	227	768	1646	1929	499
	¼ lb. MCP	23	324	794	1403	1456	1203
	½ lb. MCP	37	243	783	1714	1812	1165
	1 lb. MCP	28	315	787	1456	1892	1536
L.S.D., 5 per cent level		n.s.	n.s.	144	395	277	533
L.S.D., 1 per cent level		——	——	191	504	380	706

25. Samples were also taken for specific gravity determinations and for laboratory color ratings.

Table 3 gives the yields, specific gravity, and color ratings of tubers from the untreated and growth regulator-treated plots. In 1951, neither 2,4-D nor MCP caused yield reductions in spite of the fact that as much as 2 pounds of the growth substances were applied to some plots. This is in contrast to the results obtained in 1950. The differences between the two years may be due to the fact that in 1951 growth regulators were applied at the full bloom stage and later, whereas in 1950 the treatments which reduced yields most were applied prior to the bud stage.

TABLE 3.—*Yields of U.S. No. 1 tubers, specific gravities, and color ratings of Pontiac potatoes sprayed with one and two applications of various rates of 2,4-D and MCP. Red River Valley Potato Research Farm, 1951.*

Date of Application	Rate of Chemical per Application[2]	Yields/Acre	Specific Gravity	Tuber Skin Color Ratings
		Bushels		
Untreated	—	275	1.088	2.9
July 24[1]	¼ lb. 2,4-D	262	1.086	4.2
	½ lb. 2,4-D	240	1.086	3.6
	1 lb. 2,4-D	281	1.085	4.4
	¼ lb. MCP	284	1.086	3.5
	½ lb. MCP	270	1.086	3.6
	1 lb. MCP	286	1.086	3.5
July 24 and Aug. 17	¼ lb. 2,4-D	234	1.087	3.6
	½ lb. 2,4-D	277	1.092	4.4
	1 lb. 2,4-D	253	1.084	4.2
	¼ lb. MCP	271	1.086	3.3
	½ lb. MCP	276	1.096	3.8
	1 lb. MCP	228	1.088	4.1
L.S.D., 5 per cent level		n.s.	n.s.	0.7
L.S.D., 1 per cent level		—	—	0.9

[1]Potato plants in full bloom, tubers 1½" diameter.
[2]Applied as basal sprays.

As in 1950, none of the growth regulator treatments significantly affected the specific gravity of harvested tubers.

The tuber color ratings showed that most of the treatments improved tuber periderm color. In general, 2,4-D caused greater color intensification than did MCP. Two applications of ½ pound of 2,4-D and 1 and 2 applications of 1 pound of 2,4-D tended to improve tuber color more than did lower rates of 2,4-D or all three rates of MCP.

Experiment No. 3 — 1952:

In 1952, two experiments were conducted: one on muck soil at the University Fruit Breeding Farm at Excelsior, Minnesota and the other on silt loam soil at the Red River Valley Potato Research Farm at Grand Forks, North Dakota.

In the Fruit Breeding Farm experiment, Red Pontiac potatoes planted on April 23 were sprayed with 2,4-D at the rate of 1 pound per acre on each of four dates: June 12, June 25, July 3, and July 16. Plants sprayed on June 12 were in the early bud stage at the time of spraying and were just beginning to tuberize. On June 25 plants were in the late bud stage and had some tubers as large as 1 inch in diameter. On July 3, plants were in full bloom and had tubers up to 2½ inches in diameter. On July 16, plants had ceased blooming and had tubers up to 6 ounces in weight.

At each date of application the 2,4-D was applied as a basal spray on each side of the row so that only the lower one-third to one-half of the plant was sprayed. Each treatment was applied to plots one rod row

(16 hills) long replicated five times. All plots were harvested on September 10.

Table 4 gives the yields of U.S. No. 1 tubers and skin color ratings of these tubers from each treatment. In this experiment, one pound of 2,4-D did not significantly affect yields regardless of stage of plant growth when the 2,4-D was applied. The color data in table 4 indicate that the 2,4-D was most effective in intensifying tuber periderm color when applied after the tubers were set and before they were too close to maturity, *i.e.* when tubers were from 1 to 2½ inches in diameter.

TABLE 4.—*Yields of U.S. No. 1 tubers, and skin color ratings of Red Pontiac potatoes sprayed with 1 pound of 2,4-D on various dates. University Fruit Breeding Farm, 1952.*

Date 1 Lb. 2,4-D Applied	Stage of Plant Development at Time of Application	Yields/Acre	Tuber Skin Color Ratings
		Bushels	
Untreated	———	471	2.9
June 12	Early bud	437	3.0
June 25	Late bud	525	3.6
July 3	Full bloom	561	3.4
July 16	Post-full bloom	505	3.2
L.S.D., 5 per cent level		n.s.	0.3
L.S.D., 1 per cent level		——	0.4

Experiment No. 4 — 1952:

In the 1952 experiment conducted at the Red River Valley Potato Research Farm, 2,4-D at ½ and 1 pound per acre was applied to Pontiac and Red Pontiac potatoes at the bud stage only, at the full bloom stage only, and in repeat applications at both stages, in addition to these treatments which were applied as basal sprays, the repeat application treatment with 1 pound of 2,4-D was applied to both varieties as complete coverage sprays.

The bud stage treatments were applied on July 9 at which time the potato plants were approximately 12" tall and had tubers up to ¼ inch diameter. The full-bloom treatments were applied on July 30 at which time tubers ranged from 1" to 2" in diameter.

Each treatment was applied to single row plots 43' long. Each plot row was separated from other plot rows by single border rows. All treatments were replicated five times. The Pontiac and Red Pontiac were planted in adjacent areas and for this reason, were not directly comparable. All plots were planted on May 20 and were harvested on October 1.

Table 5 gives the yields and skin color ratings of tubers from each treatment. In this test, in contrast to that conducted on muck soil at the Fruit Breeding Farm, all 2,4-D treatments tended to reduce yields of potatoes. All 2,4-D treatments except the full-bloom stage application of ½ pound of 2,4-D significantly reduced yields of Pontiac potatoes. The yields of Red Pontiacs were reduced by all treatments except the full-bloom application of ½ and 1 pound of 2,4-D and the bud-stage application of

TABLE 5.—*Yields of U.S. No. 1 tubers and skin color ratings of Pontiac and Red Pontiac potatoes sprayed with ½ or 1 pound of 2,4-D at bud-stage and/or at full-bloom stage. Red River Valley Potato Research Farm, 1952.*

Variety and Rate of 2,4-D per Application	Date of Application[1]	Yield/Acre	Tuber Skin Color Ratings
		Bushels	
Pontiac:			
Untreated	———	272	1.2
½ lb. 2,4-D	July 9	179	1.1
½ lb. 2,4-D	July 30	261	2.2
½ lb. 2,4-D	July 9 and July 30	206	1.7
1 lb. 2,4-D	July 9	194	1.4
1 lb. 2,4-D	July 30	202	2.0
1 lb. 2,4-D	July 9 and July 30	173	1.9
1 lb. 2,4-D	July 9 and July 30[2]	157	2.2
L.S.D., 5 per cent level		45	0.3
L.S.D., 1 per cent level		61	0.4
Red Pontiac:			
Untreated	———	275	2.4
½ lb. 2,4-D	July 9	232	2.5
½ lb. 2,4-D	July 30	245	3.1
½ lb. 2,4-D	July 9 and July 30	230	3.0
1 lb. 2,4-D	July 9	246	2.3
1 lb. 2,4-D	July 30	242	3.1
1 lb. 2,4-D	July 9 and July 30	210	2.4
1 lb. 2,4-D	July 9 and July 30[2]	194	2.8
L.S.D., 5 per cent level		43	0.5
L.S.D., 1 per cent level		58	0.7

[1]July 9 — plants in bud stage, tubers to ¼" diameter; July 30 — plants in full bloom, tubers 1"-2" diameter.
[2]Applied as complete coverage sprays; all other treatments applied as basal sprays.

1 pound of 2,4-D. In general, the bud-stage applications of 2,4-D reduced yields more than did the full-bloom applications. Applications of 1 pound of 2,4-D both at the bud-stage and the full-bloom stage resulted in greatly reduced yields as compared with the single applications of 1 pound of 2,4-D. Two applications of ½ pound 2,4-D were apparently not any more toxic than single applications of either ½ or 1 pound of 2,4-D.

Complete coverage sprays of 2,4-D tended to reduce yields more than did basal sprays.

As indicated by the tuber skin color ratings in table 5, only the treatments in which 2,4-D was applied to potatoes in the full-bloom stage (July 30) improved the tuber periderm color. Since none of these treatments differed significantly from one another in their effects on tuber color, the single applications of ½ or 1 pound of 2,4-D are preferred since they were least toxic to the potatoes as measured by tuber yields.

Experiment No. 5 — 1953:

The experiments conducted in 1952 showed that from the standpoints of minimum plant injury and maximum color improvement, the best time

to apply 2,4-D is when the plants are in full bloom and tubers are 1 to 2" in diameter. These experiments also indicated that by using basal sprays the tendency of 2,4-D to reduce yields may be overcome. The 1953 experiment was carried out to compare basal *vs.* complete coverage sprays.

Red Pontiac potatoes planted at the Red River Valley Potato Research Farm on May 27 were sprayed with 2,4-D on August 7 at which time the plants were in full bloom and had tubers 1" to 2" diameter. Two rates of 2,4-D, ½ and 1 pound per acre, were applied both as basal sprays and as complete coverage sprays to single row plots 43' long. Each treatment was replicated five times. Potato yields were obtained at harvest on September 28. Tuber skin color ratings of 15 to 30-pound samples from each plot were made approximately two weeks after harvest.

The effects of the 2,4-D treatments on tuber yields and on skin color of the tubers are shown in table 6. Even though the differences in yields of tubers were not statistically significant, yields from the plots which had received 2,4-D as complete coverage sprays tended to be lower than yields from the basally sprayed and unsprayed plots. The 1 pound rate of 2,4-D was no more toxic, as measured by tuber yields, than the ½ pound rate.

All of the 2,4-D treatments improved tuber color as indicated by the skin color ratings. The basally sprayed plants which had received 2,4-D at 1 pound per acre produced significantly darker red tubers than similarly sprayed plants which had received only ½ pound of 2,4-D.

TABLE 6.—*Yields of U.S. No. 1 tubers and skin color ratings of Red Pontiac potatoes sprayed with two rates of 2,4-D applied as basal and complete coverage sprays. Red River Valley Potato Research Farm, 1953.*

Rate of 2,4-D Applied per Acre*	Spraying Method	Yield/Acre	Tuber Skin Color Ratings
		Bushels	
Untreated	———	364	2.2
½ lb. 2,4-D	Complete coverage	324	3.1
1 lb. 2,4-D	Complete coverage	323	3.1
½ lb. 2,4-D	Basal	360	2.9
1 lb. 2,4-D	Basal	376	3.3
L.S.D., 5 per cent level		n.s.	0.3
L.S.D., 1 per cent level		——	0.4

*Applied to plants in full bloom; tubers 1"-2" dia.

SUMMARY

1. Experiments were conducted during the years 1950 to 1953 to determine the influences of rate, time, and method of application of 2,4-D and MCP on yields, tuber skin color, and specific gravity of Pontiac potatoes.
2. Spraying potato vines with either 2,4-D or MCP prior to tuber setting tended to reduce yields of potatoes and were less effective in intensifying tuber color than applications made when tubers were one to two inches in diameter.

3. MCP was not as effective as 2,4-D in intensifying tuber color when applied at comparable rates.
4. Rates of one-quarter to two pounds of either 2,4-D or MCP had no effect on specific gravity of Pontiac potatoes.
5. Application of one-half to one pound of 2,4-D as a basal spray to plants in full bloom (tubers 1 - 2" diameter) was effective in intensifying tuber skin color without reducing yields. Complete coverage sprays of 2,4-D at the same rates tended to reduce potato yields.

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QUALITY OF PRESSURE-COOKED POTATOES[1,2]

E. ELIZABETH HESTER AND GRACE BENNETT[3]

Factors affecting potato quality have been investigated for many years. No precise method of predicting the quality of the cooked product has yet been devised although specific gravity is thought to be the most practical index to this quality. Compositional factors such as dry matter, alcohol insoluble solids, and starch, as well as specific gravity, were found by Heinze, Kirkpatrick and Dochterman (4) to be equally good measures for the prediction of cooking quality. Greenwood, McKendrick and Hawkins (3) suggested the desirability of supplementing specific gravity ratings with sensory methods until a more satisfactory objective method can be found.

The desirability of certain quality characteristics as mealiness will depend upon individual preference and upon the use of the potatoes. Various lots of potatoes and different specific gravity groups within the same lot are not always suitable for the same purposes. There is relatively little information concerning the suitability of certain varieties for a pressure cooked product or the effect on the quality of the product by pressure-cooking. The work described herein was undertaken to obtain information on the effect on the quality of the cooked product by pressure-cooking of pared whole or pared sliced potatoes at 5, 10 and 15 pounds pressure. Three sample lots of different variety and location were obtained for the study and three specific gravity groups of each lot were used.

MATERIALS AND METHODS

Mature U. S. No. 1 potatoes of Chippewa, Katahdin and Russet Burbank varieties were procured in 800-pound lots from Maine, Pennsylvania and Washington, respectively. Specific gravity of individual tubers was determined by the salt density method described by Clark, *et al.* (1). Potatoes in the three specific gravity groups which contained the largest number of tubers were used for the study.

The potatoes were stored up to three and one-half months at a temperature varying from 50° to 56° F. and a relative humidity varying from 82 to 98 per cent. The samples were held at room temperature, about 75° F., for 8 to 14 hours prior to cooking.

Potatoes of each specific gravity group within a variety were cooked at 5, 10 and 15 pounds pressure, both as pared whole and pared one-half inch cross-sectional slices. Three replications were made of each treatment.

Six tubers of a thickness varying by no more than 0.1 cm. comprised each cooking sample. One slice or one whole tuber in each sample was threaded with an iron-constantan thermocouple, the junction of which was centered, to measure the internal temperature.

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Cooking was done on gas burners in pressure saucepans of four-quart capacity. The samples were placed on racks in the hot pressure saucepans which contained 415 ml. of boiling distilled water below the racks. The whole tubers were considered cooked when the internal temperature of the potatoes reached 96° C. (204.8° F.). At this temperature the one-half inch slices exhibited a lack of uniformity in doneness and marked adhesion of the tissues. To obtain uniform doneness it was necessary to prevent stacking of the slices in the pan and to heat them to internal temperatures of 108°, 112° and 116° C. (226.4°, 233.6° and 240.8° F.) for 5, 10 and 15 pounds pressure, respectively.

The warm, unseasoned samples were judged by a trained panel of five members and two alternates. The quality factors judged were sloughing, mealiness, dryness, color and flavor. The judging records were essentially the same as those used by Kirkpatrick *et al* (5).

For further characterization of the raw and processed potatoes dry matter determinations were made. Quarters or halves of five cooked tubers, approximately one-third of the cooked potato slices or quarters of 10 raw tubers were diced and 200 grams were homogenized with 50 grams of water in a Waring Blendor. Duplicate samples of 40 to 42 grams were dried to a constant weight in a convection type oven at 70° C. (158° F.) for approximately 48 hours.

Results and Discussion

The average specific gravity of the tubers in the three sample lots was 1.067, 1.072 and 1.090 for the Katahdin, Chippewa and Russet Burbank varieties respectively. The specific gravity of the Russet Burbank variety was more uniform as well as higher than that of the other varieties. The largest number of tubers from each lot were distributed into the specific gravity groups as shown in table 1.

The average time of heating to the given pressure points (5, 10 and 15 pounds) was about 5 to 8½ minutes for the sliced and 3½ to 6 minutes for the whole tubers. The average time from reaching the pressure points to doneness varied from 3½ to 8½ minutes for the sliced and 16 to 24½ minutes for the whole tubers. An increase in the cooking pressure resulted in a corresponding increase in the average heating time to the pressure point and a decrease in the time from the pressure point to doneness. The sliced Russet Burbank sample generally required more time to reach a given pressure and the whole tubers from this lot required more time to reach doneness than did the other varieties. This can be accounted for partially by the greater weight of the sliced samples and the greater size of the individual whole tubers of this variety as compared with those of other varieties studied.

The mean palatability scores for sloughing and mealiness and the mean dry matter content of the samples are given in table 2. Coefficients of correlation for specific gravity, dry matter and/or quality factors for texture are given in table 3.

Sloughing of the pressure-cooked potatoes was significantly influenced by the variety, the specific gravity groups within varieties and the cooking form. Table 2 presents data which show the least sloughing of the whole tubers or slices was found in the Chippewa and the most in the Russet Burbank samples. An analysis of variance and coefficients of correlation

TABLE 1.—*Per cent distribution of tubers in the specific gravity groups used for pressure cooking.*

Chippewa, Maine		Katahdin, Pennsylvania		Russet Burbank, Washington	
Specific Gravity	Tubers	Specific Gravity	Tubers	Specific Gravity	Tubers
	Per cent		Per cent		Per cent
1.065	18.3	1.060	18.2	1.085	12.4
1.070	32.6	1.065	17.0	1.090	57.8
1.075	28.9	1.070	27.5	1.095	15.7

TABLE 2.—*Means of judges scores for palatability and the dry matter content of pressure-cooked sliced and whole potatoes.*

Variety - Location	Specific Gravity	Dry Matter[1] Raw Tubers	Dry Matter[2] Cooked Tubers		Palatability Factors[3]			
					Absence of Sloughing		Mealiness	
			Sliced	Whole	Sliced	Whole	Sliced	Whole
Chippewa, Maine	1.065	17.32	16.72	17.80	2.9	2.7	1.4	1.9
	1.070	18.51	17.60	18.87	3.0	2.6	1.5	2.0
	1.075	18.40	18.20	19.46	3.0	2.4	1.5	1.8
Katahdin, Pa.	1.060	18.22	17.76	18.86	2.8	2.6	1.4	1.7
	1.065	19.47	18.67	19.37	2.7	2.3	1.6	1.8
	1.070	19.90	19.53	20.66	2.8	2.1	1.6	1.8
Russet Burbank, Wash.	1.085	21.28	20.27	21.51	2.5	2.0	2.2	2.5
	1.090	22.64	21.53	23.49	2.0	1.6	2.6	2.6
	1.095	23.46	22.15	23.82	1.8	1.3	2.6	2.8

[1]Fresh weight basis; mean of 6 samples.
[2]Cooked weight basis; mean of 18 samples.
[3]Mean of 45 scores; a score of 3 represents the highest score, 1 the lowest.

showed that within each variety sloughing significantly increased as the specific gravity increased. About 46 per cent of the variation in sloughing among the samples was ascribed to differences in specific gravity and the greatest association of these two factors was within the Russet Burbank lot. These results are in agreement with those of Whittenberger and Nutting (10) who studied the sloughing loss of 10 gram cubes from six sample lots. They found that within each lot a significant increase in sloughing paralleled an increase in specific gravity. These workers also found that at the same specific gravity level, however, there were differences in the sloughing loss among varieties. In this study Chippewa and Katahdin samples with a specific gravity of 1.065 and 1.070 were significantly different in scores for sloughing, the Chippewa showing less sloughing than the Katahdin samples at the same specific gravity level. The dry matter content of the Chippewas was also less than the Katahdins for the same specific gravity samples.

TABLE 3.—*Coefficients of correlation between specific gravity, dry matter and/or sloughing and mealiness of pressure-cooked potatoes.*

Correlation Factors	Cooking Form	Source of Variance	
		Total	Within Varieties
Specific Gravity *versus*:		r	r
Dry Matter of Cooked Tubers	Sliced	+.831**	+.698**
	Whole	+.879**	+.747**
Absence of Sloughing	Sliced	—.690**	—.299**
	Whole	—.678**	—.480**
Mealiness	Sliced	+.798**	+.238*
	Whole	+.768**	+.131
Dry Matter of Cooked Tubers *versus*:			
Absence of Sloughing	Sliced	—.678**	—.215*
	Whole	—.757**	—.501**
Mealiness	Sliced	+.770**	+.282**
	Whole	+.703**	+.191
Mealiness *versus* Absence of Sloughing	Sliced	—.639**	—.146
	Whole	—.692**	—.466**

**Probability ≤ .01
*Probability ≤ .05

Data showing the relationship of sloughing to the dry matter of cooked samples are given in table 3. About 57 per cent of the variation in sloughing among whole and 46 per cent among sliced cooked samples was associated with dry matter. Only 25 per cent of the variability among whole samples and 5 per cent among sliced samples was owing to variation within the sample lots, indicating that much of the association between sloughing and dry matter resulted from differences among lots.

The degree of sloughing was greater for whole tubers than for potato slices. Specific gravity within one tuber is known to vary considerably and generally the highest specific gravity occurs near the periphery. This was demonstrated by Whittenberger and Nutting (10) and explained by Reeve (6) as owing to differences in cell size and starch content within different histological areas of the tuber. The cortex layer of the whole tubers was exposed to steam for a longer time than was that of the transverse slices. This might account for increased cell separation and more sloughing of the cortical layer in the whole tubers.

The judges' scores for dryness of the potato samples paralleled those for mealiness ($r = +.90$) and only the latter palatability factor will be discussed here. Mealiness was significantly affected by the variety, the specific gravity groups within varieties and the cooking form. The Russet Burbank samples were significantly more mealy (1 per cent level) than the other varieties. Within a single lot mealiness scores were significantly different for the Russet Burbanks only, samples with a specific

gravity of 1.090 and 1.095 having higher scores than those with a specific gravity of 1.085. The high coefficients of correlation between specific gravity and mealiness is largely due to differences among rather than within lots. The 0.005 interval of specific gravity within each variety, especially the non-mealy and low specific gravity lots, may not have been sufficiently different to result in a significant variation in palatability scores.

Generally whole tubers within each variety were scored as more mealy than sliced samples. Reeve (*6, 7*) found that cell rupturing and increased sogginess and gumminess are caused by increased hydration of the gelled starch. The large surface area of sliced potatoes exposed to steam would allow for greater hydration of starch granules within the internal cells of the tuber than would seem possible in whole tubers. The tendency for sliced potatoes to become more hydrated than whole tubers during cooking was shown by gain in weight of the cooked samples. The significantly higher (1 per cent level) dry matter content of cooked whole than of cooked sliced tubers might result from factors such as differences in the amount of water absorbed by or adhering to the potatoes; the amount of dry matter transferred to the condensed steam; the efficiency of the moisture determinations.

Mealiness of potatoes has been correlated with sloughing by other workers; *viz.*, r = .62 (*2*), 0.62 (*8*), and .47 (*9*). In this study the coefficients of —.64 and —.69 for sliced and whole samples show that scores for mealiness and absence of sloughing were inversely related.

The color of pressure-cooked potatoes was affected primarily by variety and to a lesser extent by the cooking form. There was little difference in the color of Chippewa and Russet Burbank samples, both receiving high color scores, but the Katahdin variety was scored significantly lower than the others. The latter samples tended to be slightly gray or darkened. The sliced samples of the Chippewas and Katahdins were superior in color to the whole tubers; this was not the case within the Russet Burbank variety.

Scores for flavor showed little deviation from the highest possible score of 3. Variety was the only factor which significantly affected the flavor of the pressure-cooked potatoes. The Katahdin samples were scored from slightly off-flavor to natural.

Summary

Three lots of mature potatoes of different variety and location were studied to obtain information on the quality on the cooked product by pressure cooking of pared whole and pared sliced potatoes. Three specific gravity groups of each lot were used. Dry matter of the raw and cooked samples was determined and the quality of the cooked products was scored by a palatability panel of five trained judges.

Variation in the cooking pressure (5, 10 or 15 pounds) appears to affect only the time of cooking and not the quality of the product.

Scores for the absence of sloughing of pressure cooked potatoes were negatively correlated with specific gravity within varieties, dry matter and scores for mealiness. The Russet Burbank samples which were higher in specific gravity and dry matter than Chippewa or Katahdin samples also showed more sloughing. Whole tubers tended to slough more than sliced samples.

Mealiness and dryness scores were positively correlated with each other and with specific gravity and dry matter. In all instances the positive relationship was more significant among than within varieties. Russet Burbank samples were scored highest in dryness and mealiness, the differences being significant. Whole tubers scored higher in these two characteristics than sliced potatoes.

All quality factors were affected more significantly by differences among the lots than by any other source of variation. Much of the difference in texture among the varieties was partially accounted for by variation in specific gravity and dry matter. These factors alone, however, cannot account for all of the differences in texture nor can they account for color and flavor variations among lots.

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A QUARTER CENTURY OF POTATO VARIETY TRIALS IN RHODE ISLAND[1]

J. E. Sheehan and T. E. Odland[2]

The Rhode Island Agricultural Experiment Station has been cooperating with the Horticultural Crops Research Branch of the Agricultural Research Service of the United States Department of Agriculture in a potato breeding and variety trial program for a period of approximately 35 years. (1) The extent of the work carried out at the Experiment Station has been to test under local conditions new seedlings developed under the Federal breeding program and to compare named varieties regarding yield, disease and insect resistance, storage quality and culinary quality. The purpose of this paper is to present briefly the data obtained over the 25-year period, 1930-1954, on the performance of the various varieties tested.

The soil on which these tests were conducted is Bridgehampton silt loam, level and well suited to potato production. Yields of over 800 bushels per acre have been produced on this soil. The potatoes were grown in rows either 24 or 32 feet in length and 12 inches apart in the row with 3 feet between rows. There were 4 replicates each year.

The potatoes were graded into U.S. No. 1 and 2 sizes. The total weight includes Nos. 1 and 2. The percentage of No. 1 tubers was calculated and can be used to determine the yields of U.S. No. 1 tubers per acre. Specific gravity determinations have been made on all varieties included in the test since 1950. The specific gravity was converted into a measurement of total solids which is used as a quality index.

Disease and insect damage or resistance was recorded for each variety and seedling in the test. Notes were taken on the storage quality after the varieties had been stored approximately six months in an underground storage cellar.

From 1930 to 1940 the standard fertilizer used consisted of 1 ton per acre of 4-8-8 banded along the side of the row. The grade was then changed to 5-10-10. This grade at 1 ton per acre was used until 1951 when an 8-12-12 grade at 1800 pounds per acre was substituted. In 1953 the rate of application of 8-12-12 was increased to 2000 pounds per acre. The fertilizer mixtures have contained approximately 2 per cent magnesium oxide. In 1951 the practice of applying 200 pounds of calcium cyanamide per acre on the rye cover crop was adopted. This contributes additional nitrogen, a small quantity of calcium, controls some weeds and aids in the decomposition of the cover crop.

From 1930 to 1946, the spray schedule consisted of a 4-4-50 Bordeaux mixture for disease control, calcium arsenate at 1½ pounds per acre for flea beetle control, and nicotine sulfate to control aphids. Beginning in 1946, DDT has replaced the calcium arsenate and Parzate has replaced the Bordeaux in the spray schedule.

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Increases in yields over the years may be attributed largely to better insect and disease control and to heavier applications of fertilizer. (2) In 1930 the fertilizer supplied approximately 80 pounds of nitrogen, 160 pounds of phosphoric acid and 160 pounds of potash per acre. These rates have increased steadily until in 1954 the fertilizer supplied approximately 200 pounds of nitrogen and 240 pounds each of P_2O_5 and K_2O per acre.

Experimental Results

The average yields of 18 varieties that have been grown over a period of five or more consecutive years are presented in table 1. Green Mountain, Irish Cobbler, and Chippewa are the only varieties that have been grown continuously for the 25-year period. Katahdins were omitted in 1939. Otherwise they have been included each year. Green Mountains outyielded Katahdins by an average of 63 bushels per acre for the 24-year average. The highest average yield for any five-year period was 652 bushels per acre produced by the Ontario variety during 1950-1954. Pontiac was next with a yield of 626 bushels for the same period. During this same period, Green Mountain produced 556 bushels per acre.

In table 2, the yields of a number of varieties that have been included in the test at various times are shown, and the average yields of these are compared with the Green Mountain variety. The highest yield, 712 bushels per acre, was produced by the Essex variety during the period 1950 and 1951. Green Mountain produced 628 bushels per acre during this same period.

The next highest yield was produced by Saco, 657 bushels per acre between 1951 and 1954 as compared to 566 for Green Mountain. The Saco potato has proved to be an excellent yielder of high quality at this station and seems destined to become an important variety in the near future. It has tended to produce off-shape tubers but this trait has not been unduly troublesome.

In 1950 specific gravity determinations were initiated. Previous to this, taste tests were used as the measure of quality each year. Results from ratings made by taste panels were, however, often rather conflicting. Although some cooking and taste tests have been made since the specific gravity determinations were begun, the main criterion now used for cooking quality is the per cent of total solids in the tubers as calculated from the specific gravity determinations.

The percentage of total solids as calculated from the specific gravity determinations are presented in table 3.

The data in table 3 show that the total solids content varies considerably between years in the same varieties. Also, it can be seen that total yield in no way affected the total solids content in that some of the varieties that were high in total solids were at times the poorest in yield.

It is interesting to note that several varieties appear in the top six each year that total solids have been determined. Green Mountain, Russet Rural, and Irish Cobbler have consistently been high in dry matter followed by Mohawk and Saco which were represented three of the four years.

The Katahdin variety replaced Green Mountain as the No. 1 potato grown in this State about 1950. Although the Green Mountain was a

TABLE 1.—*Average yields of potato varieties included in one or more 5-year periods at the Rhode Island Agricultural Experiment Station. (1930-1954).*

Variety	Average Total Yields in Bushels per Acre and Per cent No. 1 for Indicated Years											
	(1) 1950-1954 Ave.	(2) No. 1	(3) 1945-1949 Ave.	(4) No. 1	(5) 1940-1944 Ave.	(6) No. 1	(7) 1935-1939 Ave.	(8) No. 1	(9) 1930-1934 Ave.	(10) No. 1	(11) 1930-1954 Ave.	(12) No. 1
	Bus.	Per cent	Bus.	Per cent	Bus.	Per cent	Bus.	Per cent	Bus.	Per cent	Bus.	Per cent
Green Mtn.	556	96	397	95	243	85	350	86	319	90	373	90
Chippewa	529	96	387	93	251	88	348	85	362	91	369	91
Katahdin	509	97	324	94	236	85	259	92*	274	91	310	92*
Irish Cobbler	396	92	312	92	225	81	279	83	271	89	292	88
Ontario	652	93	414	91								
Kennebec	516	96	426	96								
Sebago	533	96	372	94	286	89						
Mohawk	460	98	326	96								
Sequoia	531	95	409	96								
Teton	528	97	362	96								
Pontiac	626	97										
Russet Rural	463	92										
Menominee	521	96										
Erie	441	94										
Pungo	488	98										
Houma			394	89	317	81						
Potomac			373	95	293	86						
Earlaine												
LSD @ .05	33		37								31	

*Katahdin not included in 1939.

TABLE 2.—*Yields of potato varieties included in test for less than 5 years at the Rhode Island Experiment Station during the period 1930-1954.*

Variety	Years in Test	YIELDS Total Bus./A	Per cent U.S. No. 1	Per cent of Green Mtn. Yield**
Cherokee	1952 - 1954	415	93	79
Keswick	" "	346	96	68
Canso	" "	320	92	63
Saco	1951 - 1954	657	97	117
Warba	" "	399	94	69
Essex	1950 - 1951	712	97	112
Houma*	1933 - 1938	324	85	108
Golden	1932 - 1936	256	78	83

*6 Years.
**Per cent of the average yield of Green Mountains for the same years (U.S. No. 1)

good yielder on the commercial farms, the market demanded the smooth skinned, more uniformly shaped Katahdin. Although lower in eating quality than Green Mountain, the Katahdin variety has remained in an undisputed first place. This is interesting because of the fact that in 1939 the Katahdin variety was dropped because of poor yield. (1) It was reinstated in the test the following year. Another reason for Katahdin popularity is in-

TABLE 3.—*Per cent total solids and average days to maturity of 20 potato varieties during the period 1950-1954 at the Rhode Island Agricultural Experiment Station.*

Variety	Per cent Total Solids						Average Days to Maturity
	1950	1951	1952	1953	1954	Average	
Green Mountain	19.7	19.3	16.1	17.4	18.1	18.1	143
Mohawk	18.7	19.0	17.4	15.3	19.2	17.9	144
Saco	18.6	18.5	15.2	16.0	18.9	17.5	130
Russet Rural	18.8	17.5	16.1	16.2	18.6	17.4	139
Irish Cobbler	18.9	17.8	15.8	15.6	18.2	17.3	111
Pungo	17.9	17.4	15.5	15.3	17.7	16.8	125
Warba	17.4	17.0	16.4	15.1	17.7	16.7	118
Menominee	17.2	16.6	15.4	15.5	17.4	16.4	147
Ontario	17.8	16.8	15.5	15.5	15.7	16.3	149
Katahdin	16.7	16.3	15.6	15.7	17.0	16.3	139
Erie	17.9	16.2	15.0	15.1	16.5	16.1	135
Kennebec	17.7	15.9	14.6	14.6	16.5	15.9	131
Teton	17.5	16.1	14.0	14.1	16.8	15.8	137
Sequoia	17.5	16.4	14.1	14.1	16.2	15.6	150
Sebago	17.7	15.0	14.3	14.6	15.8	15.5	147
Chippewa	16.5	15.2	13.5	15.0	16.4	15.3	131
Pontiac	16.3	15.8	14.0	13.9	15.4	15.1	135
Cherokee*	....	....	15.7	15.2	17.9	16.3	124
Canso*	....	....	14.6	14.6	17.6	15.6	128
Keswick*	....	....	15.6	17.9	19.4	17.6	126
L.S.D. @ .05	....	....	....	....	....	1.6	....

*1952-1954.

creased disease resistance and the fact that it matures earlier than Green Mountain.

The principal early potato variety grown in this State is Irish Cobbler. Early potato production, until recently, has been centered on the Eastern shores of the state. During the past several years, early potato production has spread inland with many growers using several varieties of early maturing potatoes.

Small acreages of Chippewa and Kennebec are planted each year throughout the state. Kennebec has been a high yielding potato but is dropping in popularity because of its susceptibility to Verticillium wilt. Mohawk, Ontario, Sebago, Sequoia, Pungo and Teton varieties have been grown on limited acreages during the past few years. Mohawk has been a good yielder and high in cooking quality. Ontario has been an excellent yielder, although lower in quality than Mohawk. Various varieties such as Houma, Potomac, Earlaine, and Golden have been included in the trials and dropped for various reasons, mostly because of poor yielding ability. They have been replaced by higher yielding varieties which often are more disease resistant.

One of the most serious difficulties encountered with some of the newer varieties that have come into the test from time to time has been their lack of good cooking quality. What is needed is a variety with the excellent market appeal of Katahdin and with the cooking quality of

the Green Mountain. High yielding ability and much disease resistance has been attained in many of the newer varieties.

One of the most promising potato varieties is the recently released Saco. It has produced very well at this station and has smooth cream-colored skin which should appeal to the housewife. It tends to produce some off-shape tubers, but apparently no more than does the Green Mountain variety. It is resistant to a number of troublesome diseases. In many ways it appears to be about the best new variety that has so far been included in these tests.

Summary

The Rhode Island Agricultural Experiment Station has cooperated with the United States Department of Agriculture in testing potato seedling selections and comparing them with established varieties. The seedlings and varieties have been compared with respect to yield, disease, insect resistance and cooking quality. Eighteen varieties were included in the test for five or more years. Many others were included for shorter periods.

Green Mountain and Chippewa averaged about the same yield over a 25-year period. Katahdin produced an average of 60 bushels less than these.

The Katahdin has become the leading main crop potato variety in Rhode Island. Irish Cobbler is the leading early variety.

The Green Mountain variety has been rated first in cooking quality; the Katahdin, however, has been rated highest in market appeal, and the Saco variety is still the most promising of the newer varieties that have been tested.

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NEWS AND REVIEWS

PROGRESS IN COOPERATIVE POTATO IMPROVEMENT WORK IN COSTA RICA[1]

ERNEST H. CASSERES[2]

Potatoes have been known as a food crop for a long time in Central America and the Caribbean, where the crop has been grown mostly in the cool highlands, but in a rather restricted way due to rough terrain. However, some favorable conditions in Cuba and Venezuela, for instance, allow for extensive production of the tuber at low altitudes during some parts of each year. Although popular, potatoes have generally been a high-priced item due to the ravages of diseases and insects, poor varieties or inadequate methods. Therefore, an important food has been limited mostly to the higher income groups.

Agronomic improvements in the methods of production have considerably brightened the situation. But the need for providing varieties with some genetic resistance to *Phytophthora infestans*, is still the number one problem, and with higher yielding ability and quality, it posed a problem requiring a more permanent or longer-lasting solution. The breeding of potatoes for Central America or the Caribbean was considered, several years ago, to be untimely, since the Institute estimated that the program would be costly, time-consuming and premature at that time. To circumvent those objections and get started, the Institute initiated a project in 1947[3] in Costa Rica for testing large numbers of seedlings produced in the United States. Many clones are annually discarded in the United States without any knowledge of their potential value elsewhere.

The fine cooperation received by the Institute from Dr. Donald Reddick and Dr. L. C. Peterson of Cornell University, made possible the naming and joint introduction of three new potato varieties first described in 1953 (2). These varieties were Ticanel (formerly EVI-2), Rosanel (formerly CZK-7) and Güetar (formerly DUA-2). All have the major gene R_1 for resistance to *P. infestans* and are high yielding. Harford (Figure 1), previously named and introduced in New York State in 1947, proved highly adapted to the Central American highlands and it was increased and distributed. It is no longer available in quantity in the U.S.A. but along with Güetar, it is now grown commercially in Costa Rica. Both are good yielders, but to insure this during the rainy season, it is necessary to apply fungicides due to the more recent prevalence of race 1 of the fungus. Their high quality and uniformity bring a premium on the market. Kennebec, with a similar type of resistance

[1]Accepted for publication December 5, 1955.

[2]Horticulturist, Technical Cooperation Program, Inter-American Institute of Agricultural Sciences of the OAS, Turrialba, Costa Rica.

[3]During the early phases of this work Dr. Ora Smith and subsequently Dr. H. C. Thompson of Cornell University helped organize and gave advice on the project. The encouragement and materials from Dr. F. J. Stevenson, USDA, have also been helpful.

[4]Experimental average yields reported in Costa Rica from unsprayed tests in 1952 and 1953 were: Güetar 438, Harford 373, Ticanel 244 and Kennebec 377 bushels/acre, respectively. The yields were 2 to 3 times greater than from local varieties. The local varieties Morada Blanca and Estrella in Costa Rica sometimes yield as well as those newer varieties, if blight is properly controlled, and also if circumstances are favorable.

Figure 1.—Harford potatoes produced at San Juan de Chicuá, near Irazú volcano, Costa Rica, 1949.

and productivity, has also yielded well in many of these countries.[4]

A second phase in the cooperative potato program began in 1952 with the receipt of a group of clones from Dr. W. R. Mills of Pennsylvania State University. These were combined with another large collection from Cornell, made available by Dr. L. C. Peterson. Studies with these materials in the volcanic soils of the Central Plateau of Costa Rica culminated with an appraisal in 1954, of the yield and resistance of the ten best clones, in comparison with seven named varieties. These data were the basis of a thesis presented to the Graduate School of the Institute at Turrialba by Ing. Guillermo Albornoz P., an Ecuadorean agronomist, in partial fulfillment of the requirements for the degree of *Magistri Agriculturae*. Albornoz (1) found that in three of the five tests, the following four clones consistently outyielded the older clones and the named varieties tested: 3VW-9 (from Pennsylvania), HLT-6, HDY-B (Figure 2) and HIQ-1 (from Cornell). Their superiority was due to their strong resistance to late blight and also their good yielding ability. These clones have the major genes R_1R_2 with a possibility that HLT-6 and HIQ-1 also carry gene R_4. In a comparison with the best local variety in unsprayed tests, these four clones produced twice as many tubers 1⅞" in diameter and above. For instance, without sprays against blight, clone HLT-6 yielded at the rate of 404 bushels per acre, and Estrella, the local susceptible variety, yielded at the rate of 207 bushels per acre under conditions of heavy blight. An adjacent test, sprayed seven times with fungicides,

FIGURE 2.—Differences in field resistance to *P. infestans* in unsprayed tests. Row 1, clone HDY-8 (Cornell); Row 3, Menominee, unnumbered extreme right clone B 61-3 (USDA). Near Cartago, Costa Rica, 1953.

FIGURE 3.—Discussions in a field of Harford seed potatoes. Left to right: Ing. Alvaro Coto Monge, Ing. Carlos Eduardo Robert, Costa Rican technicians; Senor Enrique Robert L., Producer; Dr. E. H. Casseres; Sr. Bruce Masis, Minister of Agriculture of Costa Rica, 1955.

indicated that yields were noticeably increased by spraying, even though the incidence of late blight was rated approximately the same in both instances. In this case, HLT-6 yielded at the rate of 538 bushels per acre, and Estrella 298. Albornoz further found that at altitudes over 6000 feet in areas or seasons where late blight was not a serious problem, satisfactory yields were produced by the following varieties: Calrose, Rosanel, Ticanel, Cherokee, Kennebec, Harford, Cortland and Estrella.

As stocks have permitted, samples of some of the named varieties and the more promising clones have been sent, upon request, to various countries including Panama, Cuba, Haiti, Nicaragua and Honduras. Encouraging results were generally obtained. Limited facilities for seed increase and the lack of low cost transportation have delayed the planting of larger areas of the above-mentioned varieties in some of these countries. A partial solution to this problem may be gradually worked out in the near future. (Figure 3.)

The third significant phase in our cooperative improvement effort has been the fusion or combination of two projects into the Cooperative Potato Program. Started early in 1955, it is operated jointly by the Ministry of Agriculture of Costa Rica and the Technical Cooperation Program of the Inter-American Institute of Agricultural Sciences. This Cooperative Potato Program works toward the improvement of potatoes in Costa Rica, and through the Institute, the benefits are extended to other countries with similar problems. It also provides a basis for collecting certain data and materials that are used in international training courses, such as the one on Potato Production and Improvement which the Institute will hold in Peru in 1956. Among the main projects underway in Costa Rica, one concerns the increase and further study of the five best clones of 1954. As soon as sufficient data and seed stocks warrant, the best ones will be named and released. Other work concerns fungicide tests and a study of the use of cut seed. Plans underway will lead to assisting some countries in the Central American and Caribbean area to determine the best varieties for their conditions and their best sources of seed, and to assist local specialists to solve their problems. (It should be mentioned here that other breeding programs underway sponsored by The Rockefeller Foundation and the Governments of Mexico and Colombia have advanced considerably and contribute a great deal to the improvement of the potato industry in those two countries.) Plans are also being drawn up to provide a minimum of facilities for starting some breeding work and for carrying out certain greenhouse tests necessary in a seed production program. In support of this cooperative effort, The Rockefeller Foundation recently made a two-year grant to the Institute.

News of the forthcoming establishment of an International Committee of the Potato Association of America has been welcomed by the Institute. It will be glad to assist such a committee in any way possible.

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AMF, QUARTERMASTER CORPS CO-DIRECT FOOD IRRADIATION PROGRAM

The first industry-government commercial evaluation program of an atomic irradiated food product for civilian and military markets is being directed jointly by the Army Quartermaster Corps and AMF Atomics, Inc., subsidiary of American Machine & Foundry Company, under a joint agreement contract with the Quartermaster Food & Container Institute (Chicago) for the Armed Forces.

Under the program several expert groups, coordinated by AMF Atomics Inc., will evaluate the application of gamma radiation upon potatoes. Potatoes were selected as the basic food product to be irradiated in this program because they are important in both civilian and military diets and because they have shown the most promise on the basis of atomic research performed to date.

Several thousand pounds of potatoes, comprising a selection of several varieties from both Maine and Idaho will be irradiated at the Atomic Energy Commission's Materials Testing Reactor at Idaho Falls, Idaho. The potatoes, before and after irradiation, will be shipped, handled, and stored under normal commercial conditions.

QM Participation

The entire program will have joint-direction and active participation of the Quartermaster Food & Container Institute for the Armed Forces. The Institute is the leading organization investigating and supporting research in the field of radiation processing of foods and has the major responsibility for the armed forces radiation preservation program.

Independent studies conducted in government laboratories and at universities under government-sponsored research programs have established that gamma radiation will preserve potatoes for periods up to 18 months. The success of this research stimulated the establishment of this program to evaluate further other radiation effects and the commercial and military logistical advantages of the low-dose gamma irradiation process to a basic food item.

The program includes six basic studies to be conducted simultaneously at several locations. Included in the studies will be extensive tests for wholesomeness based on acceptability standards recently established by the Food and Drug Administration and the Office of the Surgeon General. The direction of this phase of the program has been undertaken by the Office of the Surgeon General, Department of Army. Other studies will investigate radiation effects upon potato nutrient value and physiological changes.

To Study Costs

Process costs under various shipping, handling, and storage conditions will be studied as part of an economic analysis to determine the impact of the "extended-storage life" potato upon present commercial and military markets. The company said that it does not believe that irradiated potatoes will replace fresh potatoes as table stock in the home, but that the extended storage life resulting from the process has definite possibilities of guaranteeing a steady supply of different potato varieties to the processor throughout the year.

Food Irradiation Program

The company also stated that it is interested, as is the Army, in encouraging the establishment of similar industry-government evaluation programs to study the applications of this process to other food products. AMF believes that the gamma irradiation process has great promise of being one of the earliest and most rewarding large-scale applications of the peaceful atom. The production, processing, and distribution of food is the world's largest industry.

A wide variety of cooperating companies representing the potato processing industry will produce and examine quantities of potato chips, frozen French fries, and dehydrated, canned, and pre-peeled products from the irradiated potatoes in addition to contributing to the support of the basic studies.

Participants

Maine's Bangor and Aroostook Railroad Company will supply 50,000 pounds of potatoes for the program and will coordinate the activities of the processors in that area. Twenty thousand pounds of potatoes will be provided by the Idaho Potato Processors Association. The irradiated potatoes will be stored in facilities provided by the Bangor and Aroostook Railroad Company at Presque Isle, Maine.

Other participating companies and associated organizations other than the governmental laboratories are the J. R. Simplot Company, Boise, Ihado; Miller's Pre-Pared Potato Company, Chicago; Arrowhead Production Company, Inc., Antigo, Wis.; Tater State Potato Company, Washburn, Maine; H. C. Baxter & Brothers Company, Corrinna, Maine; and the Maine State Department of Agriculture.

The basic studies will be conducted at the Universities of Cornell, Maine and Michigan.

AMF Atomics Inc., which in April, 1955 introduced industry's first conceptual designs for food processing equipment using low-dose gamma irradiation for the preservation of bulk field crops, has designed and built special handling equipment for the potato irradiation program at the AEC's Materials Testing Reactor in Idaho.

POTATO FLAKES TO BE TESTED

An actual market test of a new product made from Maine potatoes will be made in the near future, according to a joint announcement by the Maine Potato Commission, the Maine Department of Agriculture, the Maine Agricultural Experiment Station, and the Eastern Utilization Research Branch, Agricultural Research Service, and the Market Development Branch, Agricultural Marketing Service of the USDA.

The new product will be known as Potato Flakes. The addition of water and milk will reconstitute potato flakes to make a delicious mashed potato. The method of producing potato flakes was developed by the Eastern Utilization Research Branch laboratories in Philadelphia under the leadership of Roderick Eskew.

The Maine Potato Commission will supply a carload of potatoes needed for the production of the potato flakes and will transport them to the Philadelphia laboratories of the Eastern Utilization Research Branch.

According to Millard Otto, Chairman of the Maine Potato Commission, financial and advisory aid will be given by the Commission to all phases of the marketing test including the development of a retail package. The Commission will also control the highly specialized public relations work of promoting and advertising the new product in a competitive market, and will supply transportation to the test area for the finished product.

Tentative plans call for the production of about 20,000 consumer units of potato flakes for the coming market test. The actual production of the flakes will be done in Philadelphia, and Roderick Eskew of the Eastern Utilization Research Branch will be in charge of the processing. The Product Development Section of the Market Development Branch, USDA, under Marshall E. Miller and Philip B. Dwoskin, will conduct the research in the test market and coordinate the study.

The Maine Department of Agriculture, Division of Markets, under George Chick, will cooperate by supplying two merchandising specialists who will work directly with the retail stores in the test area. The State department will also help in the design of the test packages which will probably be laminated aluminum foil envelopes in a cardboard box bearing the Maine quality blue, white, and red label.

Alvah Perry, marketing specialist of the Experiment Station, will help to develop the plans and procedures to be followed in the test market, and will conduct some of the field work on the test.

The location of the test market has not been definitely determined, but it will be in a northeastern city of more than 100,000 population, and the work will be done in the late spring or early summer months. Complete information on the sale of Maine potato flakes will be published as soon as positive results can be determined, probably early in the fall of 1956.

POTATO HARVESTER DEMONSTRATION

The Potato Marketing Board has set up a Potato Machinery Committee to advise it on how to stimulate improvements in potato machines, particularly harvesters. The Committee consists of the following members who represent the organizations indicated:

THE BOARD

Mr. J. E. Rennie (*Vice-Chairman of Board and Chairman of Committee*)

Mr. J. Arbuckle Mr. C. E. Johnson Mr. A. G. Wright

THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND

Mr. A. Herbert Carter, J.P.; Mr. S. J. Wright, M.A.

THE ROYAL HIGHLAND & AGRICULTURAL SOCIETY OF SCOTLAND

Sir Thomas Wedderspoon

THE N.F.U. OF ENGLAND AND WALES

Mr. H. Cole Tinsley, M.B.E.; Mr. J. H. Gray.

THE N.F.U. OF SCOTLAND

Mr. John Marshall.

CO-OPTED MEMBERS

Mr. W. H. Cashmore, C.B.E., B.A., N.D.A.; Mr. Roland Ward.

A demonstration of potato harvesters is being arranged for the 3rd and 4th of October, 1956. This will be the first of an annual series of demonstrations. Mr. C. E. Johnson, March, has kindly offered to allow the demonstration to be staged on his White Fen Farm at Benwick,

March, Cambs. Entries are invited from manufacturers and others of harvesters which are in production and on the market; next year it is hoped to include prototype machines. For this demonstration a potato harvester is defined as a machine which lifts potatoes and delivers them to a vehicle or to sacks.

Enquiries should be addressed to the Board at 50, Hans Crescent, Knightsbridge, London, S.W.1.

F. J. STEVENSON RETIRES

Dr. F. J. Stevenson, Principal Geneticist in charge of potato breeding research with the Section of Vegetable Crops, of the United States Department of Agriculture, at Beltsville, Md., retired on May 31, 1956 after 26 years with the Department.

Dr. Stevenson is a native of Prince Edward Island, Canada, where he obtained his elementary and high school education. He obtained his B. S., M. S., and PhD degrees from the State College of Washington.

After serving the college as assistant Farm Crops Specialist for 4 years he became an Instructor and then Superintendent of Practice Teaching for 3 years. Dr. Stevenson then served as assistant Professor of Agronomy and Plant Genetics at the University of Minnesota for 5 years after which he joined the staff of the U.S.D.A. as a geneticist.

He has headed the National Potato Breeding Program since 1930 which has grown to include cooperative breeding and testing research with 34 states, Alaska, and Canada and several other foreign countries.

Under the leadership of Dr. Stevenson this Program has enjoyed outstanding success. Thirty five varieties have been named and released under Dr. Stevenson's leadership since 1930 and in 1954, 62 per cent of all the certified seed grown in the U. S. originated from the National Potato Breeding Program.

Among these varieties there are several that are resistant to or immune from several of the virus, fungus and bacterial diseases and insect pests as well as those that have superior market and cooking quality.

Dr. Stevenson was honored by the Potato Association of America by being elected an honorary life member in 1952. "Steve", as he is called by his host of friends across the nation, also was honored by being elected vice president of the Potato Association of America in 1941 and president in 1942, 1943 and 1944 and is the only person to serve as president for 3 terms — an indication of the esteem of his colleagues.

We wish for "Steve" many more fruitful years of service to the potato industry as well as much deserved leisure and happiness in following his hobbies and chosen field of research with Red Dot Foods Inc. at Madison, Wisconsin.

Robert V. Akeley, a native of Presque Isle, Maine and for many years an associate of Dr. Stevenson, has been promoted to head the potato breeding program. "Bob" Akeley is well qualified to take over the leadership of this program and we wish him every success in his efforts.

—John C. Campbell

"PREPARED" FROZEN FOOD PRODUCTION UP 67 PER CENT

Production of "prepared" frozen food increased 67 per cent from 1954 to 1955, according to data released recently by the U.S. Department of Agriculture's Agricultural Marketing Service. (See table)

"Prepared" frozen foods are those which have received one or more preparatory operations usually performed in the home, such as cooking, partial cooking, or blending.

This increase was a part of the food industry's trend towards production of convenience items. The 67 per cent figure is based upon a 70 per cent reply from the industry in a recently conducted survey. The response is estimated to represent 80 to 90 per cent of total production of "prepared" frozen foods.

"Prepared" frozen foods account for about 8 per cent of total frozen food production—about equal to the current volume of frozen fruit production.

Of the 12 categories of "prepared" frozen foods surveyed, FROZEN POTATO products constitute the largest single category in terms of pounds produced. Production has more than doubled from 1954 to 1955.

Others that increased more than 100 per cent during the same period were side dishes and hors d'oeuvres.

A more complete report on the production of specific frozen items will be released later.

PRODUCTION OF PREPARED FROZEN FOODS, 1954 AND 1955

Prepared Frozen Food Category	Total Production[1]		1955 Compared with 1954
	1954	1955[2]	
	Pounds	*Pounds*	*Per cent*
A. Hors D'Oeuvres	208,300	460,500	+121
B. Soups	Incomplete	Incompl te	
C. Meat dishes	55,434,812	91,263,663	+ 65
D. Poultry dishes	59,628,834	94,135,339	+ 58
E. Fish dishes		:	
Fish sticks[3]	49,962,400	65,000,000	+ 30
F. Shellfish dishese			
G. Nationality foods	16,994,993	27,701,897	+ 63
H. POTATO PRODUCTS	87,662,943	183,409,475	+109
I. Side dishes	1,291,729	3,655,867	+183
J. Baked products	16,190,776	21,449,658	+ 12
K. Dessert pies	27,195,745	44,762,473	+ 65
L. Other	1,446,498	2,048,538	+142
Totals	319,017,030	533,887,410	+ 67

[1]Based upon 70 per cent reply from the industry. It probably represents between 80 to 90 per cent of total production.
[2]Estimated production.
[3]Source: U.S. Department of Interior, Fish and Wildlife Service.

CIP INSTITUTE DESIGNATES JULY 6-16 AS "FRIEND-CHIP WEEK"

Striking a note in honor of summer conviviality, Harold B. Cregar, president of the National Potato Chip Institute, revealed that the Institute has designated July 6-16 as "FRIEND-CHIP Week."

The Chip Institute prexy said:

"Friendliness is the essence of picnic fun and outdoor entertaining. Planks of our campaign will be laughter and song.

"We are planning a 'FRIEND-CHIP' trophy to the national television personality, who in the opinion of the Institute, has contributed most to the spirit of friendliness.

"What could be more natural," queried Cregar, "than to select an attractive, chipper 'MISS FRIEND-CHIP'?"

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NEW PROTECTION AGAINST CHEMICALS, SPRAYS AND DUSTS USED IN AGRICULTURE

Tested and approved by the Department of Agriculture's Pesticide Chemicals Research Section is the new American Optical R-5058 Respirator as giving adequate protection against inhaling of many toxic chemicals widely used in farming today. It is designed specifically as a lightweight, compact device for protection against inhalation of agricultural insecticides applied in the field in the form of dusts, sprays, mists and vapors.

The respirator is recommended for protection against synthetic organic insecticides (chlorinated hydrocarbons, fluorinated hydrocarbons, organic phosphates, dinitro compounds, organic thiocyanates, organic mercury compounds, and organic sulphur compounds); natural organic insecticides (alkaloids, pyrethrins, and rotenoids); inorganic insecticides (compounds of antimony, arsenic, barium, bismuth, boron, copper, fluorine, lead, selenium, sulphur, thallium and zinc); herbicides, repellents, mothproofing agents, nutritional agents, plant hormones, defoliant agents, blossom thinners, wood preservatives, oils, solvents and detergents.

Further information on this and other types of respirators is available from American Optical Company, Safety Products Division, Southbridge, Mass.

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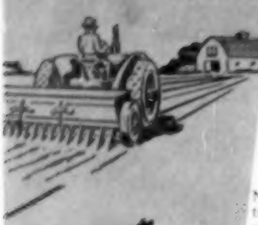

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